RMD - 80/3

Nitrogen Oxides Emissions for Alberta

Alberta
ENVIRONMENT

91-02977/

NITROGEN OXIDES EMISSIONS FOR ALBERTA

1976 to 1979

by

R.R. PETERS

H.S. SANDHU

Research Management Division

Alberta Environment

December 1980

RMD-80/3

PREFACE

Nitrogen oxides (NO_x) are a major class of air pollutants released to the atmosphere by many industrial and transportation sources. Estimated NO_x emissions from major sources in Alberta are reported in this inventory. Existing monitoring of NO_x emissions is insufficient for computing precise values. Estimates based upon stack surveys and extrapolations should be considered coarse at best and we consider our values to have about 20% uncertainty. We welcome your suggestions and comments for improving these estimates and would attempt to incorporate your input in future versions of this report.

Many individuals, companies, and agencies were contacted for supplying information on NO_x emissions. We thank all of them in a collective way. However, special thanks are due to R. Rudolph previously of the Research Management Division of Alberta Environment, M. Winning of Shell Canada, staff of Pollution Control and Standards and Approvals Divisions of Alberta Environment, staff of Air Pollution Directorate of Environment Canada, and staff of Alberta Energy Resources Conservation Board, for their excellent co-operation and assistance.

TABLE OF CONTENTS

Page

PREFACE i

LIST OF TABLES iii

REFERENCES CITED 12

LIST OF TABLES

Page

1. Total Nitrogen Oxides Emissions from Major Sources in Alberta.....1
2. Nitrogen Oxides Emissions from Major Sources in Alberta.....2
3. Nitrogen Oxides Emissions from Fertilizer Plants in Alberta.....3
4. Nitrogen Oxides Emissions from Chemical Plants in Alberta.....4
5. Nitrogen Oxides Emissions from Refineries in Alberta.....5
6. Nitrogen Oxides Emissions from Natural Gas Processing Plants in Alberta.....7
7. Nitrogen Oxides Emissions from Oil Sands Plants in Alberta.....8
8. Nitrogen Oxides Emissions from Power Plants in Alberta.....9
9. Nitrogen Oxides Emissions from Natural Gas and Heating Fuel Combustion Sources in Alberta.....10
10. Nitrogen Oxides Emissions from Transportation Sources in Alberta.....11

Table 1. Total nitrogen oxides emissions (tonnes/year) from major sources in Alberta.[a]

Source[b]	1976	1977	1978	1979
Industrial Processes[c]	137 723	165 287	154 374	147 239
Fuel Combustion[d]	46 216	47 182	52 390	58 861
Transportation[e]	85 328	92 578	100 281	108 473
TOTAL	269 267	305 047	307 045	314 573

[a] Estimated as NO_2.

[b] Source classification is same as Environment Canada's(1978) inventory report.

[c] Includes fertilizer plants, chemical plants, refineries, natural gas processing plants, and oil sands plants.

[d] Includes power, residential, commercial, industrial, and general heating sources.

[e] Includes gasoline and diesel motor vehicles and railways.

Table 2. Nitrogen oxides emissions (tonnes/year) from major sources in Alberta.[a]

Source	1976	1977	1978	1979
INDUSTRIAL PROCESSES				
Fertilizer Plants	4 500	10 643	8 248	8 174
Chemical Plants	3 370	3 340	3 460	4 420
Refineries	1 893	1 917	1 933	1 949
Natural Gas Processing	127 960	133 387	132 133	116 696
Oil Sands Plants	N/A[b]	16 000	8 600	16 000
Subtotal	137 723	165 287	154 374	147 239
FUEL COMBUSTION				
Power Plants	28 935	30 289	35 584	39 876
Residential	2 397	2 513	2 867	3 034
Commercial	3 508	3 698	4 083	4 292
Industrial	10 956	10 074	9 602	10 572
Heating	420	608	254	1 087
Subtotal	46 216	47 182	52 390	58 861
TRANSPORTATION				
Gasoline & Diesel Motor Vehicles	74 127	81 657	88 400	96 171
Railways	11 201	10 921	11 881	12 302
Subtotal	85 328	92 578	100 281	108 473
GRAND TOTAL	269 267	305 047	307 045	314 573

[a] Estimated as NO_2.

[b] N/A = Not Available.

Table 3. Nitrogen oxides emissions (tonnes/year) from fertilizer plants in Alberta.[a,b,c]

Plant (Location)	1976	1977	1978	1979
Esso Chemical Canada (Redwater)	310	248	185	248
Cominco (Calgary)	386	347	389	374
Cominco (Carseland)	N/O[d]	2 897	2 897	2 897
C.I.L. (Carseland)	N/O	129	129	129
Western Co-op Ltd.[e] (Calgary)	838	838	838	838
Western Co-op Ltd. (Medicine Hat)	2 920	3 060	686	564
Sheritt Gordon Mines Ltd. (Fort Saskatchewan)	46	46	46	46
Canadian Fertilizer Ltd. (Medicine Hat)	N/O	3 078	3 078	3 078
TOTAL	4 500	10 643	8 248	8 174

[a] Estimated as NO_2

[b] The emission results reflect emissions mainly due to process production as opposed to utility usage purposes and constitute the best data available. Sources such as boiler stacks are not required to be monitored under current licence conditions as emission rates from these sources are low in relation to the other sources within the plants (personal communication, L. Begoray, Air Quality Control Branch, Alberta Environment, 1980).

[c] Estimated from stack surveys and 330 operational days unless otherwise noted.

[d] N/O = Not Operational.

[e] 1980 estimate used for 1976-79 emissions based on stack surveys and 330 operational days.

Table 4. Nitrogen oxides emissions (tonnes/year) from chemical plants in Alberta.[a,b]

Plant	1976	1977	1978	1979
Alberta Gas Chemicals	70	40	160	20
Celanese Canada	2700	2700	2700	2700
Dow Chemical	300	300	300	1100
Alberta Gas Ethylene	N/0	N/0	N/0	300
Subtotal	3070	3040	3160	4120
Other Plants[c]	300	300	300	300
TOTAL	3370	3340	3460	4420

[a] Estimated as NO_2.

[b] Estimates are based on stack surveys, license requirements and 330 operational days. The values presented in the table are considered to be representative of overall NO_x emissions from the plants. These computations were based on stack surveys conducted at the plants. Some small sources of NO_x at the plants are not required to be surveyed. It is believed that their contributions to the overall NO_x emissions would be insignificant .(personal communication, W. MacDonald, Air Quality Control Branch, Alberta Environment, 1980)

c Estimated for unsurveyed plants by the Air Quality Control Branch of Alberta Environment.

Table 5. Nitrogen oxides emissions (tonnes/year) from refineries in Alberta.[a]

Plant (Location)	1976	1977	1978	1979
Esso[b] (Edmonton)	902	902	942	982
Esso[c] (Cold Lake)	N/A	N/A	N/A	N/A
Gulf[b] (Edmonton)	531	555	531	507
Gulf[d] (Calgary)	-	-	-	-
Texaco[b] (Edmonton)	460	460	460	460
Shell[e] (Bowden)	-	-	-	-
Shell[c] (Peace River)	N/A	N/A	N/A	N/A
Husky Oil[d] (Lloydminster)	-	-	-	-
Subtotal	1893	1917	1933	1949
Others[f]	-	-	-	-
TOTAL	1893	1917	1933	1949

[a] Estimated as NO_2.

[b] Estimated from stack surveys and usual operational time of 365 days/year.

[c] Data not available at time of compilation.

[d] Largest single NO_x source would be a poorly controlled incinerator--no estimates.

[e] Essentially less than 1 tonne per day of NO_x emissions--no estimate of emissions.

continued...

Table 5. Concluded.

[f] At this time, there are approximately 38 licenced prototype heavy oil recovery facilities that operate at production rates of anywhere from a couple of hundred barrels per day up to 15 000 barrels/day. The most significant facilities are the Esso Cold Lake facilities and the Shell Peace River plant.

Two basic classes of facility can be defined; steam stimulation recovery processes and flame front recovery processes. This refers to the manner in which the heavy oil is made less viscous and is separated from the sand formation in which it is contained. Treatment at the plants is very basic and is designed simply to produce a product that can be transported and handled by the refineries.

The most significant sources of NO_x emissions are, therefore, the power boilers and compressors used for injection of either steam or air. These emissions can thus be estimated on the basis of size and fuel consumed. It should be noted that some facilities burn the oil they produce part of the time and natural gas the rest of the time. Some of the plants only operate a few months of the year, although most of the larger facilities operate year round.

There has been some discussion as to whether or not NO_x is emitted from well vents of flame front operations. This question has not been properly assessed. Draeger tube testing conducted on well vent gas at one facility at an unspecified time in their cycle showed no NO_x. Similarly, typical well vent gas analyses have not shown NO_x, although generally this is not being looked for (personel communication, D. Lee, Air Quality Control Branch, Alberta Environment, 1980).

Table 6. Nitrogen oxides emissions (tonnes/year) from natural gas processing plants in Alberta.[a,b]

Source	1976	1977	1978	1979
Compressors				
Sweet Plants	38 561	40 161	39 819	35 245
Sour Plants	80 427	83 880	83 049	73 409
Subtotal	118 988	124 041	122 868	108 654
Heaters and Boilers				
Sweet Plants	8 375	8 723	8 648	7 507
Sour Plants	597	623	617	535
Subtotal	8 972	9 346	9 265	8 042
TOTAL	127 960	133 387	132 133	116 696

[a] Estimated as NO_2.

[b] The estimates are based on fuel data taken from Statistics Alberta (1976-79) and fuel usage fractions (percentage of plant fuel used for compressors and heaters and boilers) obtained from Dr. M. Winning (personal communication, Shell Canada Ltd., 1980). Plant fuel is defined by Statistics Alberta as coming from: (1) field, (2) gathering system, (3) injection, and (4) plants. Flared quantities are not involved in any of the data. Emission factors were obtained from Environment Canada (1978):

Compressors--55 400 $kg/10^6 m^3$

Heaters and Boilers --3702.3 $kg/10^6 m^3$

Table 7. Nitrogen oxides emissions (tonnes/year) from oil sands plants in Alberta.[a,b]

Source[c]	1976	1977	1978	1979
Suncor[d]	N/A	16 000	8 600	4 500[e]
Syncrude	N/0	N/0	N/A[g]	11 500[f]
TOTAL	N/A	16 000	8 600	16 000

[a] Estimated as NO_2

[b] Other types of oil sands plants produce heavy oil by means other than open pit mining and are covered in the reference of Lee (personal communication, Air Quality Control Branch, Alberta Environment, 1980) in Table 5.

[c] An area emission figure has been estimated for 1976 (Shelfentook 1978).

[d] Previously known as Great Canadian Oil Sands.

[e] Estimated from stack surveys.

[f] Estimated from production efficiency records and projected NO_x emissions.

[g] Started operation in Summer 1978. Estimate not available.

Table 8. Nitrogen oxides emissions (tonnes/year) from power plants in Alberta.[a]

Plant	1976	1977	1978	1979
Wabamun[b]	6 955	4 556	4 804	5 518
Sundance[b]	8 874	13 487	17 739	20 527
Rossdale[c]	2 014	1 905	2 221	993
Cloverbar[c]	1 686	1 322	1 641	2 333
Battle River[d]	1 675	2 197	2 082	3 343
H.R. Milner[d]	1 833	1 059	1 124	979
Jasper[e]	105	327	549	447
Medicine Hat[e]	1 365	1 008	996	1 308
Subtotal	24 507	25 861	31 156	35 448
Steam Plants[f]	328	328	328	328
Other Plants[g]	4 100	4 100	4 100	4 100
TOTAL	28 935	30 289	35 584	39 876

[a] Estimated as NO_2.

[b] Industry capacity figures (based on time utilized and amount of time of operation) and stack survey results are the basis of estimates.

[c] Edmonton Power provided detailed gross power output figures which allowed calculation of a capacity figure for yearly operations. Capacity figures and stack surveys were utilized for emission estimates.

[d] Industry operational time per year and percentage output factors were used with stack surveys for emission estimates.

[e] Estimates based on stack surveys and 300 operational days.

[f] Only one stack survey available, operating approximately at 50% capacity; assumed linear relation to other steam plants.

[g] An estimate for smaller plants that run on diesel and natural gas. Estimate based on total megawatts produced and an emission factor from Environment Canada (1978).

Table 9. Nitrogen oxides emissions (tonnes/year) from natural gas and heating fuel combustion sources in Alberta.[a]

Source	1976	1977	1978	1979
Natural Gas[b]				
Residential	2 397	2 513	2 867	3 034
Commercial	3 508	3 698	4 083	4 292
Industrial	10 956	10 074	9 602	10 572
Subtotal	16 861	16 285	16 552	17 898
Heating Fuel[c]	420	608	254	1 087
TOTAL	17 281	16 893	16 806	18 985

[a] Estimated as NO_2.

[b] Natural gas consumption data were provided by Canadian Western Natural Gas Co. Ltd. and Northwestern Utilities Ltd. These data excluded gas used in fertilizer and natural gas processing industries. Emission factors used in the calculation of these estimates were obtained from U.S. Environmental Protection Agency (1977):

Residential = 36.28 kg per 28 317 m^3

Commercial = 54.42 kg per 28 317 m^2

Industrial = 104.31 kg per 28 317 m^3

Irrigation = 1541.95 kg per 28 317 m^3
(included under industrial category)

Gas Alta. = 36.28 kg per 28 317 m^3
(included under residental category)

[c] Heating fuel consumption data were provided by Alberta, Department of Treasury (1980). Emission factors used for emission estimates were obtained from Environment Canada (1978):

8.16 kg per 3785.45 L

Table 10. Nitrogen oxides emissions (tonnes/year) from transportation sources in Alberta.[a]

Source	1976	1977	1978	1979
Gas and Diesel[b] Motor Vehicles	74 127	81 657	88 400	96 171
Railways[c]	11 201	10 921	11 881	12 302
TOTAL	85 328	92 578	100 281	108 473

[a] Estimated as NO_2.

[b] The figures are based upon emission inventories done by Alberta Environment for Edmonton and Calgary for 1973. An extrapolation to the whole province was done by using the percentage of fuel sales. A similar extrapolation was done for the following years based on percentage increase of fuel sales.

[c] The figures are based on fuel oil consumption data (Alberta, Department of Treasury 1980) and an emission factor from Environment Canada (1978) of 44 kg per 1000 L.

REFERENCES CITED

Alberta, Department of Treasury. 1980. Fuel sales for Alberta. Unpublished data.

Environment Canada. 1978. A nationwide inventory of emissions of air contaminants (1974). Environmental Protection Service, Air Pollution Control Directorate. Hull, Quebec, Canada. Report 3-AP-78-2. 145 pp.

Shelfentook, W. 1978. An inventory for atmosphere emissions in the AOSERP study area. Prep. for the Alberta Oil Sands Environmental Research Program by SNI Tottrup Ltd. AOSERP Report 29. 58 pp.

U.S. Environmental Protection Agency. 1977. Compilations of air pollutant emission factors. Office of Air Quality Planning and Standards. Research Triangle Park, N.C. 509 pp.